# OKLAHOMA ACADEMIC STANDARDS

# SCIENCE

## FRAMEWORK

PHYSICAL SCI: OVERVIEW

The Oklahoma State Department of Education is excited to announce the release of the first resources being offered through the Oklahoma Academic Standards Science Frameworks. The Science Frameworks represent curricular resources developed by Oklahoma teachers to help teachers translate standards into classroom practice. The *Framework Overviews* represent how a group of Oklahoma teachers, at a given grade level, might bundle performance expectations/standards found in the Oklahoma Academic Standards for Science.[1] **Bundling** is how teachers would **group performance expectations/standards** for the purpose of developing **instructional units of study.**

Once bundled, the *Science Framework* writers were then charged with completing **four categories of information** that coincided with the bundle of performance expectations/standards. The categories provide insight into how the Science Framework writers collaborated to begin to translate standards into classroom instruction. The guidance provided in the categories does **not** represent a **directive** to teachers, schools or districts for classroom instruction and should not be viewed as such.

The Oklahoma State Department of Education would like to say a special thank you to the Oklahoma educators who participated in developing the Oklahoma Science Framework Overviews, Doug Paulson of the Minnesota State Department of Education who served as a consultant, Lawton Public Schools and to Quentin Biddy, the project director.

## Science Framework Writers

| | | | |
|---|---|---|---|
| Solomon Bayouth | Megan Cannon | Wendy Howard | Jenny Thompson |
| Elizabeth Beck | Mandi Cloud | Traci Richardson | Sarah Vann |
| Colleen Bennett | Benjamin Cottingham | Georgia Smith | Megan Veldhuizen |
| Rachel Brown | Jennifer Crabb | Stacey Stapelton | Tammy Will |
| Randi Butcher | Maria Harris | Amy Tankersley | Susan Wray |

"The vision of the Overviews is to provide a resource for teachers that encourages them to embrace the new standards and implement them effectively in their classrooms. The suggestions provided by the frameworks project **do not** have to be implemented exactly as they are written and are **not required** to be a successful teacher, but **serve as a guide** to setting up effective lessons that will help students meet the necessary levels of success in a science classroom." - Oklahoma Science Framework Project Writer

[1] Download the Oklahoma Academic Standards for Science at http://sde.ok.gov/sde/science.

## How To Read This Document

Below you will find short descriptions about each of the sections of information provided in this document. If you have questions regarding the *Framework Overviews*, please contact Tiffany Neill at 405-522-3524 or Tiffany.Neill@sde.ok.gov

## **Science Framework Overview:** Sections

### In Lay Terms

This section aims at providing a brief introduction to the goals outlined in the Performance Expectation Bundles/grouping of standards.

### Three Dimensional Storyline

This section aims at providing a comprehensive instructional storyline of how the three dimensions represented in the Performance Expectation Bundles intertwine to support students engaging in science and engineering practices, crosscutting concepts and disciplinary core ideas. Keep in mind each performance expectation includes one **science and engineering practice**, one **crosscutting concept** and one **disciplinary core idea**. The **color-coding** in this section allows teachers to see where components of these three dimensions appear in the instructional storyline. To find out more about the three dimensions and how they are incorporated into the Oklahoma Academic Standards for Science, review pages 7-8 in the Oklahoma Academic Standards for Science[2] or check out the OKSci PD on Your Plan Module series, Transitioning to the Oklahoma Academic Standards for Science[3].

### Lesson Level Performance Expectations

This section aims at providing **scaffolding three-dimensional learning targets** that teachers can design instruction around to meet the end goal of the Performance Expectation(s) represented in the bundles or units of study. Keep in mind the performance expectations represent the things students should know, understand and be able to do to show proficiency at the end of instruction they participate in. A teacher can **utilize** the **Lesson Level Performance Expectations** in each bundle **as a way to develop a series of instruction** to meet the end goals of the performance expectations. For example, a teacher can develop or use a lesson, which may allow students to participate in instruction that covers some of the Lesson Level Performance Expectations, but not all. In this case the teacher would then develop or conduct another lesson that covers other Lesson Level Performance Expectations in the bundle.

### Misconceptions

This section aims at providing research-based misconceptions that students frequently have related to the science concepts (disciplinary core ideas) embedded in the Performance Expectation Bundles along with matching correct conceptions.

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[2] Download the Oklahoma Academic Standards for Science at http://sde.ok.gov/sde/science.

[3] Access the OKSci PD on Your Plan Modules at: https://www.evernote.com/l/AUXXlQC11VZDeLmUkOMPpjhKeJjqS-R8gww

## **Bundle:** Defining and Calculating Energy

**HS-PS3-1**

*Students who demonstrate understanding can:*

**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**

**HS-PS3-2**

*Students who demonstrate understanding can:*

**Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.**

## In Lay Terms

The energy of a system depends on the motion of the system, as well as the interactions that occur within the system. Energy is always changing from one kind to another, but the total energy of the system is always the same. Energy can take many forms such as motion, sound, light, and heat. The amount of energy available is mathematically calculable, and determines what the system is capable of doing.

## Three Dimensional Storyline

Energy is a concept that crosses all disciplines within science. It is a quantitative property that encompasses the motion and interactions of matter and radiation within a system. Energy can be transferred and stored in a variety of forms (light, motion, sounds, electrical and magnetic fields, and thermal energy). For students to understand this concept, they need to actively work to create and/or revise a computational model that explains the phenomenon that the energy of a system with multiple components is conserved. They can calculate the change in the energy of one component when they change the energy of the other component(s) in the system. For example, students could plan and conduct an investigation to determine the relationship between kinetic and thermal energy in a closed system. Students could also investigate the relationship between the amounts of thermal energy transferred between different components in a closed system. This means that they will be able to predict an accurate change in temperature based on the amount of heat or heated material they add to the system. Once students understand how the components of this model function in the system, they can then use the model to predict the behavior of a different system of energy at the macroscopic scale.

The students can then develop models that demonstrate energy can be accounted for as either motions of particles or energy stored in fields. This is an opportunity for students to highlight that energy cannot be created or destroyed, it only moves between one place to another, between objects and/or fields, or between systems. An example of this could include, shining a light (incandescent) on a system and seeing a change in temperature or the ability of the system to do work. Models could include diagrams, drawings, descriptions, and computer simulations. These models can be used to support explanations, predict phenomena, analyze systems, and/or solve problems around the concepts of energy at the microscopic scale.

## Lesson level Performance Expectations

- Students can create a model from evidence to illustrate that energy is a property of a system that depends on the motion and interactions of the parts of a system.
- Students can create a model that generates data to explain that though energy comes in many different forms, it is always conserved.
- Students can gather and interpret data that represents that energy at the large scale can take the form of motion, sound, light, or heat.
- Students can create a model that will relate energy on the large scale to energy at a microscopic or quantum level.
- Students can use mathematical thinking to explain that the total amount of energy in the system will always equal the energy transferred into or out of the system.
- Students can create a simulation of a system to show that energy can be transformed from one form to another.
- Students can apply techniques of algebra and functions to create a computational model to quantify the amount of stored or kinetic energy in a system.
- Students can use mathematical thinking to show that the kinetic energy of an object is related to the mass and speed of an object.
- Students can use evidence to argue that a certain change in system will cause specific and predictable results.
- Students can use a model to construct an explanation of how energy limits what can occur in any system.

| Misconceptions | Accurate Concept |
|---|---|
| 1. One form of energy cannot be transformed into another form of energy (e.g. chemical energy cannot be converted to kinetic energy). | 1. Energy can be transformed (converted) within a system. |
| 2. Energy is not transferred from one object to another unless those objects are in direct contact with each other. | 2. Energy can be transferred from one system to another (or from a system to its environment) in different ways: by conduction, mechanically, electrically, or by radiation (electromagnetic waves). |
| 3. Energy can be destroyed. | 3. Regardless of what happens within a system, the total amount of energy in the system remains the same unless energy is added to or released from the system. |
| 4. Energy cannot be transferred from one object to another. | 4. Regardless of what happens within a system, the total amount of energy in the system remains the same unless energy is added to or released from the system. |
| 5. Energy is associated mainly with human beings, not inanimate objects. | 5. Motion energy (kinetic energy) is associated with the speed and the mass of an object. |

## References

- (Brook & Driver, 1984) http://assessment.aaas.org/misconceptions/NGM002/247
- (AAAS Project 2061, n.d.) http://assessment.aaas.org/misconceptions/NGM057/248
- (Kruger, 1990; Trumper, 1998) http://assessment.aaas.org/misconceptions/NGM060/249
- (AAAS Project 2061, n.d.). http://assessment.aaas.org/misconceptions/NGM059/249
- (Finegold & Trumper, 1989; Kruger, 1990; Kruger, Palacino, & Summers, 1992; Leggett, 2003; Liu & Tang, 2004; Solomon, 1983; Stead, 1980; Trumper, 1990, 1993, 1997a, 1997b; Trumper & Gorsky, 1993; Watts, 1983) http://assessment.aaas.org/misconceptions/EGM001/215

## **Bundle:** Atomic Properties and the Periodic Table

**HS-PS1-1**

Students who demonstrate understanding can:

**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.**

**HS-PS1-2**

Students who demonstrate understanding can:

**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, knowledge of the patterns of chemical properties, and formation of compounds.**

## In Lay Terms

The periodic table can be used to identify atomic behaviors/properties and predict the outcome of chemical reactions.

## Three Dimensional Storyline

Atoms have a specific composition that determines the chemical and physical properties of a substance. Students can use models to understand the structure of each atom, which will contain a nucleus of protons and neutrons, surrounded by electrons. Students can then analyze models of different elements to discover the patterns in the periodic table, i.e. atoms are ordered on the periodic table horizontally by the number of protons in the nucleus (and vertically by similar chemical properties) and vertically based on the arrangement of valence electrons, or the outer level electrons. These patterns on the periodic table can assist students in explaining each element's reactivity with other elements.

Matter has the ability to interact, and many substances can react with other substances undergoing a chemical change that creates new substances. Students can construct explanations for how matter interacts using the patterns found within the periodic table. Students can then establish a claim support it with evidence about the reactivity of several different elements knowing that elements are arranged in patterns, horizontally by the number of protons and vertically by chemical similarities.

In a chemical reaction there are the same number of atoms before the reaction as after the reaction showing that matter is conserved.  If matter is conserved then mass is also conserved. It is essential to understand that the properties associated with each element will affect its ability to react chemically with other elements and/or substances.

These concepts connect into other major science concepts that relate to both life science and earth and space science.  At a basic level, the atomic makeup of an element will give a substance its chemical and physical properties.

## Lesson Level Performance Expectations

- Students can explain through a model the subatomic structure of an atom.
- Students can construct an explanation for why the patterns shown in the periods of the periodic table have atomic masses that increase as you move from left to right.
- Students can apply scientific ideas to explain why similar chemical properties are placed in columns.
- Students can explain through a model how the columns of the periodic table reflect the patterns of the valence electrons.
- Students can explain through a model how the rows in the periodic table reflect the patterns of atomic valences or electron levels of an element.
- Students can conduct an investigation to explore the properties of a variety of substances and relate them to their location on the periodic table.
- Students can plan and conduct an investigation to show that matter is conserved even as it changes structure and phase.
- Students can apply investigative data to explain that the total number of atoms in the reactant and the product are the same.

| Misconceptions | Accurate Concept |
|---|---|
| 1. The Periodic Table provides only an element's name, symbol, atomic number, and atomic mass. | 1. Elements are placed on the Periodic Table according to repeating patterns of physical and chemical properties, as well as reactivity patterns. |
| 2. The more subatomic particles contained in an atom, the larger the atom. | 2. Atomic size decreases going across a period of the table due to increasing nuclear charge. Atomic size increases down a group of elements due to addition of energy levels. |
| 3. During a chemical reaction, the original substance vanishes. | 3. All matter is conserved, just broken apart and rearranged to form new molecules/substances. |
| 4. The chemical bond is a rigid, physical entity made of matter. | 4. A chemical bond is an attractive force not a physical thing at all. |
| 5. The electron cloud contains electrons, but it is made of something else. | 5. The electron cloud is a "cloud" because of the motion of the electron in orbit around the nucleus, and mostly made up of empty space. |
| 6. The periods are based on the increase of the relative atomic mass. | 6. Periods on the periodic table are based on the energy levels an atom has. |
| 7. The atomic number of an atom does not characterize the chemical properties of the atom. | 7. The atomic number of an atom indicates the number of protons an atom has which determines what element and therefore the chemical properties it possesses. |
| 8. When the total number of electrons are changed in the atom, periodic properties do not change. | 8. Changing the number of electrons an atom has will change its reactivity with atoms around it. |

## References


- Montana Frameworks http://www.opi.mt.gov/Pdf/CurriculumGuides/Curriculum-Development-Guide/Periodic-Table-Unit.pdf
- Ohio Resource Center http://www.ohiorc.org/pm/science/SciCDMisconceptions.aspx?cid=14
- Beyond Appearances: Students' misconceptions about basic chemical ideas http://www.rsc.org/images/Misconceptions_update_tcm18-188603.pdf
- International Online Journal of Primary Education http://www.iojpe.org/ojs/index.php/IOJPE/article/download/321/397

## **Bundle**: Acceleration and Things That Cause Acceleration

**HS-PS2-1**

*Students who demonstrate understanding can:*

**Analyze data and use it to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.**

**HS-PS2-5**

*Students who demonstrate understanding can:*

**Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.**

## In Lay Terms

Applying a force to an object will cause acceleration. The size of this acceleration is determined by the mass of the object and the size of force applied. An applied force will cause a change in the types of energy in the system, therefore the energy found in waves and the interaction of waves and their environment will cause accelerations.

## Three Dimensional Storyline

In this bundle, students will explore cause and effect relationships as objects and fields interact at varying scales. For example, magnets apply forces to objects, causing them to accelerate, which requires an energy input. Students should plan and conduct observations in order collect empirical data about the relationship between force, mass, and acceleration. As students analyze the data from these investigations they should be able to discover patterns that help define the relationship between the force, mass, and acceleration of an object. According the Newton's Second Law of Motion force is equal to mass times acceleration. As force on an object increases so does the acceleration it experiences. Likewise, the larger the mass of an object, the larger the force required for acceleration. Students should be able to explain this relationship using a model, which could be physical, visual, and/or mathematical in nature.

As forces are observed at the macroscopic level they can be explained by fields such as gravitational, electric, or magnetic fields. When objects interact in a system energy is conserved and can be transferred between objects through the interaction of these fields. In order to provide evidence that these two items are directly related, students should plan and conduct investigations to observe the relationship between the strength of electric current and the strength of a magnetic field induced in an electromagnet, considering the possible confounding variables and evaluating the design of their electromagnet. Inversely students should also be able to explain using evidence that electric currents can be induced by changing magnetic fields. Magnetic fields can apply a force- through the movement of charged particles (i.e. at the most basic level electrons and protons) - that can permeate through space and can transfer energy. Students should be able to construct an explanation using a model about how this relationship between electric current and magnetic field function.

## Lesson Level Performance Expectations

- Students can analyze data to make a claim that predicts the effect of force and mass on acceleration.
- Students can use mathematical thinking to develop a model that shows the proportional relationship between force, mass and acceleration.
- Students can plan and conduct an investigation to show that magnets and electric currents produce fields that can apply a force.
- Students can use a directional hypotheses to set up an investigation that shows that electric charges and changing magnetic fields are the cause of electric fields.
- Students can analyze data from an investigation to explain that forces acting at a distance (gravitational, electrical, and magnetic) transfer energy through space.
- Students can plan and conduct an investigation to show that electrical energy can either be stored in a battery or transmitted by currents.

## Misconceptions

1. When a force acts on an object in the direction of the object's motion, the speed of the object will stay the same for a while and then increase and stay at the new higher speed.
2. Electrical sources such as batteries transfer energy all the time, even when there is not a complete circuit.
3. Energy cannot be transferred from one object to another.
4. Energy can be transformed into a force

## Accurate Concept

1. If a force acts on an object in the same direction as the direction of its motion, the object's speed will continue to increase while the force is acting.
2. Energy can be transferred from one system to another (or from a system to its environment) in different ways: by conduction, mechanically, electrically, or by radiation (electromagnetic waves).
3. Energy can be transferred within a system. Regardless of what happens within a system, the total amount of energy in the system remains the same unless energy is added to or released from the system.
4. Energy can be transformed (converted) within a system.

## References


- (AAAS Project 2061, n.d.) http://assessment.aaas.org/misconceptions/FMM120/258
- (AAAS Project 2061, n.d.) http://assessment.aaas.org/misconceptions/NGM056/248
- (AAAS Project 2061, n.d.) http://assessment.aaas.org/misconceptions/NGM059/249
- (AAAS Project 2061, n.d.) http://assessment.aaas.org/misconceptions/NGM005/247

## **Bundle:** Momentum

**HS-PS2-1**

*Students who demonstrate understanding can:*

**Analyze data and use it to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.**

**HS-PS2-2**

*Students who demonstrate understanding can:*

**Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.**

**HS-PS2-3**

*Students who demonstrate understanding can:*

**Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.***

## In Lay Terms

Momentum is determined by the speed of an object and the direction it is traveling (velocity) of an object and the object's mass. This momentum is conserved as long as there are no new objects added to the system. If a new object is added then the momentum will change in order to maintain a balance in the overall system. Devices can be designed and tested, that will use this balance of forces to minimize the effects of a change in momentum on an object.

## Three Dimensional Storyline

Conservation of momentum is a concept that can be examined through several methods; for example two objects interacting within a system of motion, or cause and effect relationships between the impacts of two objects. In this performance expectation, students will use algebraic thinking to model that the total momentum of two objects colliding is conserved when there is no net force acting on the system as a whole. They will need to observe and collect data involving two objects colliding in either a real-world scenario or a virtual lab. After they discover how the overall system interacts, they can make a prediction about the interaction between two new objects. They can use mathematical representations to describe and/or support their predictions and explanations.

To show an understanding of the concept of momentum, specifically that momentum is conserved in a collision, students should apply scientific and engineering ideas to design a device that minimizes the force of a collision on a macroscopic object. Examples of this could include, airbags, springs, restraints, or anything that could increase the length of time the collision occurs. This device will need to be tested and refined based on scientific observations made of the cause and effect relationship between the interactions which occur in a collision. The final product should remain within the engineering constraints (financial, societal, or biological) that have been defined.

## Lesson Level Performance Expectations

- I can analyze data to make a claim that predicts the effect of force and mass on acceleration.
- I can use mathematical thinking to develop a model that shows the proportional relationship between force, mass and acceleration.
- I can analyze data showing that momentum is conserved in a closed system.
- I can use mathematical representations to show the relationship between mass and velocity in a closed system.
- I can use data that supports an overall claim that any change to a system in terms of momentum is balanced by a change outside of the system.
- I can carry out an investigation showing that the more time in which a collision occurs will decrease the force acting on an object.
- I can apply scientific ideas to solve a design problem relating to minimizing the force on an object during a collision while remaining in the societal constraints of risk and cost.

## Misconceptions

1. Momentum is not a vector.
2. Momentum is the same as force.
3. Momentum is not conserved in collisions with "immovable" objects.

## Accurate Concept

1. Momentum is a vector quantity.
2. Momentum is mass in motion, whereas forces are pushes or pulls applied to an object or mass.
3. Momentum is conserved in a collision.

## References


- Helping Students Learn Physics Better http://phys.udallas.edu/C3P/Preconceptions.pdf

## **Bundle:** Properties of Chemical Reactions and Conservation of Energy

**HS-PS1-5**

*Students who demonstrate understanding can:*

**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.**

**HS-PS1-7**

*Students who demonstrate understanding can:*

**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**

## In Lay Terms

Chemical reactions always start and end with the same amount of atoms, though they will be arranged differently. Furthermore; how fast the reaction occurs, and if energy is stored or released is all determined by the collisions of the molecules that make up the chemical reaction. The number of collisions of molecules during a chemical reaction can be influenced by temperature as well as the amount of particles present during a reaction.

## Three Dimensional Storyline

Matter has the ability to interact in many ways. Some of these interactions, termed chemical reactions, form new substances. Students should engage in constructing an explanation about the reactivity of several different elements utilizing the patterns of the periodic table based on chemical properties of elements to support their claims. Students can establish claims and carry out investigations to support them in order to determine the effect of temperature, kinetic energy, and different concentrations on chemical reactions (e.g. temperature increases, kinetic energy increases, resulting in the increase of collisions that occur between the molecules in a chemical reaction). After the students have recognized the patterns in reactivity rates of the reacting particles, they can use that information to redesign an investigation to suit a specific goal.

Through planned investigations students can gather data to identify that the number of atoms that enter a chemical reaction as reactants is equal to the number of atoms exiting a reaction as products showing that matter is conserved. Students can use mathematics and computational thinking to support their claims that matter and mass are conserved during a chemical reaction, and algebraic equations can be used to solve for unknown masses of components involved in a chemical reaction. The crosscutting concept of energy and matter should be used to explicitly highlight that in a closed system the overall energy is conserved when a chemical reaction occurs.

When students understand the concept that matter is conserved, they can then connect this concept with the idea that the properties associated with each element will affect its ability to react chemically with other substances. Thus, the students can use this knowledge to describe and predict what will happen with basic chemical reactions, highlighting the conservation of energy and matter.

## Lesson Level Performance Expectations

- Students can apply scientific evidence to explain chemical processes in terms of the patterns that exist when collisions occur on the molecular level.
- Students can provide an explanation using patterns to communicate that the rates of chemical reactions are based on the number of collisions that occur in a mixture.
- Students can apply computational thinking to explain the relationship between the change of kinetic energy of a substance and sum of the bond energies of that group of molecules.
- Students can use mathematical representations to support the claim that atoms, and therefore all matter, are conserved in a chemical reaction.
- Students can use linear algebraic functions to predict the mass of chemical reactions.

| Misconceptions | Accurate Concept |
|---|---|
| 1. Production of a gas or the dissolution of a solute causes a loss in mass. | 1. Although the substance changes forms, the atoms are still there. In a closed system you will see no change in mass. |
| 2. All collisions result in a chemical reaction. | 2. A chemical reaction will only happen if a collision occurs, however more requirements, such as orientation and available kinetic energy, must also be met. |
| 3. During a chemical reaction, the original substance vanishes. | 3. All matter is conserved, just broken apart and rearranged to form new molecules/substances. |

## References


- *Practice* 4.3 (2003): 279.
- Barker, Vanessa. "Beyond Appearances: Students' Misconceptions About Basic Chemical Ideas." *A Report Prepared for the Royal Society of Chemistry*
- Ohio Resource Center: http://www.ohiorc.org/pm/science/SciCDMisconceptions.aspx?cid=14
- Beyond Appearances: Students' misconceptions about basic chemical ideas *http://www.rsc.org/images/Misconceptions_update_tcm18-188603.pdf*

## **Bundle**: The Use of Electromagnetism and Its Effect on the Bioshpere

**HS-PS4-1**

***Students who demonstrate understanding can:***

**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**

**HS-PS4-2**

*Students who demonstrate understanding can:*

**Evaluate questions about the advantages and disadvantages of using a digital transmission and storage of information.***

**HS-PS4-4**

*Students who demonstrate understanding can:*

**Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.**

## In Lay Terms

Electromagnetic radiation when absorbed can be converted to thermal energy, cause damage to living cells, or even cause materials to release electrons therefore being converted into electrical energy. In addition, the use of electromagnetic waves can be used to send information worldwide and has become an integral part of our society. It is important to determine the full impact of the advantages and disadvantages of ou current use of and exposure to electromagnetism.

## Three Dimensional Storyline

The late 20th century saw an explosion in the exploitation of wave technology to improve communication, medicine, information and energy technologies. As a group, society has deemed that the advantages of this technology outweigh the disadvantages, especially in the realm of communication and information technologies. However, as the technology proceeds to encroach deeper into everyday life, new questions need be considered and old arguments reevaluated. To narrow this vast area of study, focus on the use of waves to digitize information; the methods that are used to achieve this for storage and communication as well as the pros(i.e. stability of the data once stored) and cons(i.e. security) of such practices. These questions should delve into the positives of the technology to see if it can be improved upon, and the negatives to probe for ar problems that would cause the discontinuation of the overall use of the technology. Furthermore, the questions should evaluate the systems thes technologies create for stability both within the technology themselves and their overall effect on society.

Wave properties can provide a unique connection to how matter can interact with energy. The speed at which waves travel is related to the wavelength and frequency of the wave. The students will use a mathematical representation to support a claim that shows this relationship. The speed of a wave can also be affected by the type of wave and the material through which it travels. Students can plan and conduct investigations using a variety of media; such as air, water, or solids in order to model this relationship. Patterns appear when waves are subjected to different frequencies and cause and effect relationships can be used to explain how this concept shows up in the different media listed above.

While evaluating the technological systems which use wave technology, students should examine data concerning the possible effects of using wave energy. Many claims have been made about the effects caused by the use and conversion of energy on biological and thermal systems. Other information exists which would cause the further exploitation of the energy in waves to power the diverse instruments which make our society what it is today. Students should obtain information concerning these claims from multiple sources; scientific and technological texts media reports. Students should also verify the data when possible and evaluate the validity of these claims. Using this information, students shou be able to communicate the causes and effects of society's current and continued uses on the environment, life and society.

## Lesson Level Performance Expectations

- Students can use mathematical expressions to show the effect that changing the wavelength or frequency of a wave will have on the wave speed.
- Students can use algebraic functions to show the cause and effect relationship between the type of wave, the medium it travels through, and the wave's speed.
- Students can analyze data from a planned investigation to determine that when light and longer wavelength electromagnetic radiation are absorbed by matter they are converted to thermal energy.
- Students can argue based on evidence from investigations that there is a pattern in the transformation of electromagnetic radiation to thermal energy based on the wavelength of the radiation.
- Students can evaluate the claim that shorter wavelength electromagnetic radiation (i.e. uv and shorter) can ionize atoms and cause damag to living tissue.
- Students can create a model showing that photoelectric materials emit electrons when they absorb light of a high enough frequency.
- Students can evaluate questions about the dependence of modern civilization on technological systems.
- Students can evaluate arguments for the advantages and disadvantages caused by the storing and transmitting digital information using waves.
- Students can ask questions and evaluate designs about modifications engineers make to improve technology in terms of improved performance versus cost and risk.

| Misconceptions | Accurate Concept |
| --- | --- |
| 1. Only the sun transfers energy in the form of electromagnetic | 1-2. Energy can be transferred from one system to another (or from a |

radiation
2. Only hot objects can transfer energy in the form of electromagnetic radiation.
3. The particles of a wave move with the wave.

system to its environment) in different ways: by conduction, mechanically, electrically, or by radiation (electromagnetic waves).
3. Only energy is transferred with the wave, the particles always return their original position

## References


- (AAAS Project 2061, n.d.) http://assessment.aaas.org/misconceptions/NGM036/248

## **Bundle:** The Use of Energy, Its Conservation, and Equilibrium

**HS-PS3-3**

*Students who demonstrate understanding can:*

**Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.***

**HS-PS3-4**

*Students who demonstrate understanding can:*

**Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).**

## In Lay Terms

Energy can be seen in multiple ways and be used to accomplish goals by building machines that capture and use that energy. These machines will transfer one type of energy to another form until a balance between the amounts of the different forms of energy is reached. Show this by building a machine to accomplish a task.

## Three Dimensional Storyline

Energy can be present in many different forms at the macroscopic scale, such as motion, sound, light, and thermal energy. Thermal energy provides an opportunity to model how overall energy is conserved throughout a system. If there is a difference in the amount of thermal energy it will try to distribute that energy throughout the system. Students will plan and conduct an investigation to provide evidence that the transfer of thermal energy happens within a closed system. This will allow them to see a very basic picture of the second law of thermodynamics. Part of this process will involve students selecting appropriate tools to collect, record, analyze, and evaluate data. They will use this data to support explanations for the phenomena and they will evaluate the design of the investigation to ensure that variables are controlled.

The students will take their knowledge of energy and apply it in a real-world or problem-based scenario. Engineers play a crucial role in today's society. They apply scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Students can take this opportunity to research and learn about engineers and how they have impacted the world today.

Students are going to take the role of an engineer and apply scientific knowledge, specifically about energy on the macroscopic scale (motion, sound, light, and thermal energy), and design, build, and refine a device that converts one form of energy into another form of energy. The changes of energy and matter in system can be described in terms of energy that flows into, out of, and within that system. Since energy cannot be created or destroyed, the total energy within the system will remain the same. The students need to continue the role of an engineer and provide evidence of how their design meets the specific need of the performance expectation.

## Lesson Level Performance Expectations

- Students can use valid and reliable evidence to show that energy can be manifested in multiple forms, including; motion, sound, light, ar thermal energy.
- Students can design, evaluate, and refine a device that quantifiably converts one form of energy to another while remaining within a give set of societal constraints of risk and cost.
- Students can plan an investigation that will produce data supporting the fact that energy cannot be created or destroyed.
- Students can plan an investigation producing data that supports the idea that all systems evolve towards equilibrium.
- Students can plan and conduct an investigation to gather quantitative data to determine that energy can transfer between components i a system and/or between systems.

## Misconceptions

1. Thermal energy is not related to the kinetic energy of the molecules that make up an object.
2. Motion energy is not transformed into thermal energy, especially when there is no noticeable temperature increase.
3. One form of energy cannot be transformed into another form of energy (e.g. chemical energy cannot be converted to kinetic energy).
4. When two objects at different temperatures are in contact with each other, thermal energy is transferred from the warmer object to the cooler object and "coldness" or "cold energy" is transferred from the cooler object to the warmer object .

## Accurate Concept

1. Thermal energy of an object is associated with the disordered motions c its atoms or molecules and the number and types of atoms or molecule: of which the object is made.
2. Energy can be transformed (converted) within a system.
3. Energy can be transformed (converted) within a system.
4. Energy can be transferred from one system to another (or from a syster to its environment) in different ways: by conduction, mechanically, electrically, or by radiation (electromagnetic waves).

## References


- (AAAS Project 2061, n.d.). http://assessment.aaas.org/misconceptions/EGM062/217
- (Brook & Wells, 1988; Kesidou & Duit, 1993). http://assessment.aaas.org/misconceptions/NGM003/247
- (Brook & Driver, 1984). http://assessment.aaas.org/misconceptions/NGM002/247
- (AAAS Project 2061, n.d.). http://assessment.aaas.org/misconceptions/NGM016/248